Section 5 · Tech & Design ·

Feeding the World

Reading Preview

Key Concept

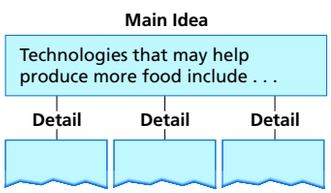
- What technologies may help farmers produce more crops?

Key Terms

- precision farming
- hydroponics
- genetic engineering

Target Reading Skill

Identifying Main Ideas As you read the section, write the main idea in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.



Lab zone Discover Activity

Will There Be Enough to Eat?

1. Choose a numbered tag from the bag that your teacher provides. If you pick a tag with the number *1* on it, you're from a wealthy country. If you pick a tag with the number *2*, you're from a middle-income country. If you pick a tag with the number *3*, you're from a poor country.
2. Find classmates that have the same number on their tag. Sit down as a group.
3. Your teacher will serve your group a meal. The amount of food you receive will depend on the number on your tag.
4. As you eat, observe the people in your group and in the other groups. After you eat, record your observations. Also, record how you felt and what you were thinking during the meal.

Think It Over

Predicting Based on this activity, predict what effect an increase in the world's population would have on the world's food supply.

More than 6 billion people live on Earth today. By the year 2050, the population could grow as large as 10 billion. Think about how much food will be needed to feed the growing population. How will farmers be able to grow enough food?

Farmers and scientists are hard at work trying to find answers to this question. Farmers are using new technologies that make farming more efficient. People are developing methods for growing crops in areas with poor soil. In addition, scientists are developing plants that are more resistant to insects, diseases, and drought.

A food market in Turkey ▶

Lab zone Discover Activity

Skills Focus Predicting L1

Materials bags; tags; cooked rice, dry cereal, or raisins

Time 20 minutes

Tips For a class of 30, make 3 #1 tags, 5 #2 tags, and 22 #3 tags. Divide the food into three equal portions, and then divide each portion by the number of students in each group. Group 1 should have the largest portions, Group 3 the smallest. **CAUTION:** *Check for food allergies among students.*

Expected Outcome Students may feel guilt, pity, envy, anger, resentment, or gratefulness.

Think It Over Food is already scarce in some countries. As world population increases, even less food will be available.

Section 5 Feeding the World

Objectives

After this lesson, students will be able to

A.5.5.1 Identify technologies that may help farmers produce more crops.

Target Reading Skill

Identifying Main Ideas Explain that identifying main ideas and details helps students sort the facts from the information into groups. Each group can have a main topic, subtopics, and details.

Answers

Possible details: Precision farming—uses satellite images and computers to determine the amount of water and fertilizer needed; Hydroponics—plants are grown in solutions of nutrients instead of in soil; Genetic engineering—genetic material is altered to produce plants with useful qualities

All in One Teaching Resources

- Transparency A50

Preteach

Build Background Knowledge L2

Comparing Farming Methods

Ask students to describe their idea of a typical farm from 100 years ago. *(Most will say it was small, one family worked on it, and it grew only enough food for the family.)* Then, have students describe a contemporary farm. *(Farms exist in all sizes, from the small family farm to very large agribusiness that grow food for many people.)* Ask students to speculate on what a farm will be like in 100 years. *(Accept all reasonable responses.)*

Instruct

Precision Farming

Teach Key Concepts L2

Benefits of Precision Farming

Focus Tell students that in the U.S., irrigation represents the largest demand for freshwater withdrawal.

Teach Ask: **What variables can be manipulated in precision farming?** *(Amount of water and fertilizer)* **What are the benefits?** *(More food per plant, more plants per field, increased harvests)* **How can precision farming help the environment?** *(It can minimize the amount of water and fertilizer used. Decreased fertilizer use leads to less runoff into streams, lakes, and rivers.)*

Apply Ask students to infer additional way data from satellites can be used on farms. *(Data can be collected and analyzed over time, allowing farmers to evaluate the effects of new methods or products.)* **learning modality: verbal**

Hydroponics

Teach Key Concepts L2

Farming Without Soil

Focus Tell students that *hydro* is the Latin word for water.

Teach Ask: **What is hydroponics?** *(A farming method relying on solutions of nutrients rather than soil)* **What is the benefit?** *(It allows crops to grow in areas with poor soil.)*

Apply Ask students to identify a location that would benefit from hydroponics. *(Possible answer: salty soil near the ocean)* **learning modality: logical/mathematical**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Feeding the World*

Student Edition on Audio CD

FIGURE 23
Precision Farming
The map on this tractor's computer screen shows the makeup of the soil in a farm's fields. The map was obtained by satellite imaging.
Relating Cause and Effect *How can precision farming benefit the environment?*

Precision Farming

On the farms of the future, satellite images and computers will be just as important as tractors and harvesters. Such technologies will allow farmers to practice **precision farming,** a farming method in which farmers fine-tune the amount of water and fertilizer they use to the requirements of a specific field.

First, satellite images of a farmer's fields are taken. Then, a computer analyzes the images to determine the makeup of the soil in the different fields. The computer uses the data to prepare a watering and fertilizing plan for each field.

Precision farming can benefit farmers by saving time and money. It also increases crop yields by helping farmers maintain ideal conditions in all fields. Precision farming would also benefit the environment because farmers use only as much fertilizer as the soil needs. When less fertilizer is used, fewer nutrients wash off the land into lakes and rivers. As you read in Chapter 3, reducing the use of fertilizers is one way to prevent algal blooms from damaging bodies of water.

Hydroponics

In some areas, people cannot grow crops because the soil is so poor. For example, on some islands in the Pacific Ocean, the soil contains large amounts of salt from the surrounding ocean. Food crops will not grow in salty soil.

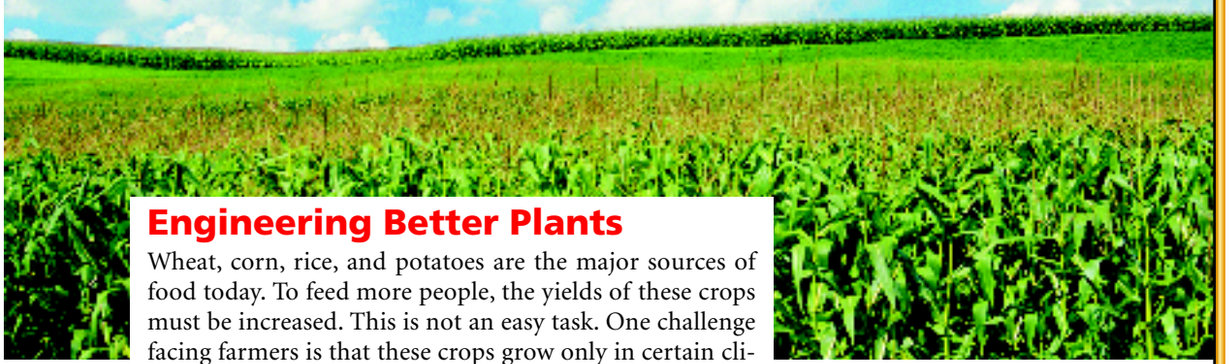
On these islands, people may soon use hydroponics to grow food crops. **Hydroponics** (hy druh PAHN iks) is a farming method in which plants are grown in solutions of nutrients instead of in soil. Usually, the plants are grown in containers in which their roots are anchored in gravel or sand. The nutrient solution is pumped through the gravel or sand. **Hydroponics allows people to grow crops in areas with poor soil to help feed a growing population.** Unfortunately, hydroponics is a costly method of growing food crops.

Reading Checkpoint **What is hydroponics?**

Differentiated Instruction

English Learners/Beginning L1
Comprehension: Prior Knowledge
Write the first sentence under *Engineering Better Plants* on the board. Write a list of food crops commonly grown in your region of the U.S. Ask students to name or draw a picture of the main food crops grown in their native country. **learning modality: visual**

English Learners/Intermediate L2
Comprehension: Prior Knowledge
Pair students with students proficient in English. Have them make two columns and list foods and the plants they are from, for example, Bread/Wheat and Corn/Tortilla. Make sure the list includes foods from the students' native countries. **learning modality: verbal**



Engineering Better Plants

Wheat, corn, rice, and potatoes are the major sources of food today. To feed more people, the yields of these crops must be increased. This is not an easy task. One challenge facing farmers is that these crops grow only in certain climates. Another challenge is that the size and structure of these plants limit how much food they can produce.

One technique scientists are using to address these challenges is called genetic engineering. In **genetic engineering,** scientists alter an organism's genetic material to produce an organism with qualities that people find useful.

Scientists are using genetic engineering to produce plants that can grow in a wider range of climates. They are also engineering plants to be more resistant to damage from insects. For example, scientists have inserted genetic material from a bacterium into corn and tomato plants. This bacterium is harmless to humans. But its genetic material enables the plants to produce substances that kill insects. Caterpillars or other insects that bite into the leaves of these plants are killed. Today, farmers grow many kinds of genetically engineered plants.

Reading Checkpoint **What is one way that genetic engineering can help farmers produce more food?**

Go Online NSTA SciLinks
For: Links on plants as food
Visit: www.SciLinks.org
Web Code: scn-0155

Section 5 Assessment

Target Reading Skill **Identifying Main Ideas** Use your graphic organizer to help you answer the questions below.

Reviewing Key Concepts

1. **a.** **Listing** Name three technologies that farmers can use to increase crop yields.
   b. **Explaining** Describe one farming challenge that each technology addresses.
   c. **Making Judgments** Which technology do you think holds the most promise for the future? Support your answer with reasons.

Writing in Science

Interview Suppose you could interview a farmer who uses precision farming. Write a one-page interview in which you ask the farmer to explain the technology and its benefits.

Writing in Science

Writing Mode Interview

Scoring Rubric

4 Includes description and benefits of precision farming in an interview style; goes beyond requirements, for example, describes traditional farming methods
3 Includes all criteria but does not go beyond requirements
2 Includes only brief description
1 Includes incomplete or inaccurate descriptions

Lab zone Chapter Project

Keep Students on Track Help students collect seeds. Find the average number of seeds produced per plant for each group of students. If time permits, have students plant these seeds to begin the life cycle again. Emphasize that this second cycle should be similar to the one they just observed. Check student's data tables for completeness and make sure their diagrams are labeled properly.

Engineering Better Plants

Go Online NSTA SciLinks
For: Links on plants as food
Visit: www.SciLinks.org
Web Code: scn-0155

Download a worksheet that will guide students' review of Internet resources on plants as food.

Teach Key Concepts L2

Better Plants Through Genetics

Focus Tell students that in 2000, 25 percent of the corn grown in the U.S. was genetically modified.

Teach Ask: **What is genetic engineering?** *(The process of altering an organism's genetic material)*

Apply Ask: **What is the benefit of plants that produce a natural insecticide?** *(They do not have to be sprayed with synthetic pesticides.)* **learning modality: verbal**

Monitor Progress L2

Answers

Figure 23 Less fertilizer is used.

Reading Checkpoint A farming method of growing plants in nutrient-rich water and without soil

Reading Checkpoint Making organisms that are resistant to harmful insects

Assess

Reviewing Key Concepts

1. a. Precision farming, hydroponics, genetic engineering **b.** Increases crop yields; grows crops in areas with poor soil; makes plants resistant to insects **c.** Answers will vary. Possible answer: Hydroponics because plants can be grown in various locations without soil

Reteach L1

Summarize the benefits of the technologies that increase crop yields.

All in One Teaching Resources

- Section Summary: *Feeding the World*
- Review and Reinforce: *Feeding the World*
- Enrich: *Feeding the World*

Lab zone Technology Lab

Design and Build a Hydroponic Garden

Prepare for Inquiry

Key Concept

To design and build a hydroponic garden, students evaluate building materials and control variables for maximum plant growth.

Skills Objectives

After this lab, students will be able to

- Design an effective hydroponic garden
- Measure and record data concerning plant growth and health
- Evaluate an initial design and determine changes or adaptations

Class Time 40 minutes design and set up, 10 minutes a day for 14 days for observation; 40 minutes for design adjustments, 10 minutes a day for a second 14 day interval of observation

All in One Teaching Resources

- Lab Worksheet: *Design and Build a Hydroponic Garden*

Advance Planning

Provide a variety of plants or flowers such as lettuce, spinach, tomatoes, peppers, nasturtiums, and morning glories. Prepare a nutrient solution using nitrogen, phosphorous, and potassium. Or, use a commercially available nutrient solution. Provide students with materials useful for anchoring plants—perlite, sand, small gravel, or rock wool are useful alternatives. If photoperiod is not designated as an independent variable, leave lights on 24 hours a day for rapid growth in the system.

Lab zone Technology Lab

• Tech & Design •

Design and Build a Hydroponic Garden

Problem

Can you design and build a system for growing plants without soil?

Skills Focus

designing a solution, redesigning

Materials

- potted plant
- 2 different types of seedlings
- nutrient solution
- empty 2-liter soda bottles
- paper towels
- optional materials provided by your teacher

Procedure

PART 1 Research and Investigate

1. Copy the data table onto a sheet of paper.
2. Carefully examine the potted plant your teacher gives you. Think about all the factors that are required in order for the plant to grow. List these factors in the first column of the data table.
3. Use your knowledge of plants and additional research to fill in the second column of the data table.
4. For each factor listed in the table, decide whether or not it is "essential" for plant growth. Write this information in the third column of the data table.

PART 2 Design and Build

5. To test whether soil is essential for plant growth, design a "garden" system for growing plants without soil. Your garden must
   - include at least two different types of seedlings
   - use only the amount of nutrient solution provided by your teacher
   - be built using materials that are small and lightweight, yet durable
6. Sketch your garden design on a sheet of paper and make a list of the materials you will use. Then obtain your teacher's approval and build your garden.

PART 3 Evaluate and Redesign

7. Test your garden design by growing your plants for 2 weeks. Each day, measure and record the height of your plants and the number of leaves. Also note the overall appearance of your plants.
8. Evaluate your design by comparing your garden and plants with those of your classmates. Based on your comparison, decide how you might improve your garden's design. Then make any needed changes and monitor plant growth for one more week.

Data Table

Factor Required for Plant Growth	What This Factor Provides for the Plant	Essential or Nonessential?

Safety

Make sure all students wash their hands immediately after handling plants and any time they handle the nutrient solution. Review the safety guidelines in Appendix A.

Guide Inquiry

Introduce the Procedure

- Have sketches of several simple hydroponic systems—milk carton and rock wool, soda bottle, floating foam raft, basic wick, and rudimentary ebb and flow—available as references.
- Make sure students understand that the anchoring materials are not soil substitutes.

Analyze and Conclude

1. **Identifying a Need** In Part 1, did you list soil as a factor required for plant growth? If so, did you think it was an essential or nonessential factor? Explain your thinking.
2. **Designing a Solution** How did the information you gathered in Part 1 help you in designing your garden in Part 2? How did your garden design provide for each of the essential growth factors you listed?
3. **Redesigning** What changes did you make to your garden design and why? Did the changes lead to improved plant growth?
4. **Working With Design Constraints** How did the design constraints in Step 5 limit your design? How did you overcome those limitations?
5. **Evaluating the Impact on Society** Hydroponic gardens are planned for future space flights and as a way to grow plants in cold climates. Explain why hydroponic gardens are a good choice for each of these situations. Then, identify two more situations in which hydroponic gardens would be a good choice and explain why.

Communicate

Create a brochure highlighting the benefits of hydroponic gardening. Be sure to provide details about how a plant's needs are met and about the problems that hydroponic gardens could solve.

Extend Inquiry

Communicate Encourage students to create a brochure that is interesting to read and holds the reader's attention. Supporting details should be included, including results of the student's experiences with designing a hydroponic garden.

Troubleshooting the Experiment

- Remind students that their designs should include a way to recycle nutrient solution not absorbed as it passes through the plant roots.
- Make sure all gardens have approximately the same amount of light in a day. Use artificial plant lights and natural light if available.

Expected Outcome

- A successfully designed garden should show growth by the end of 2 weeks. Healthy gardens with 24 hours of light a day can produce a crop of spinach or soft-leaved lettuce in about 4 weeks.
- Students recognize that given an adequate supply of nutrients, plants can grow—and thrive—without soil.

Analyze and Conclude

1. Students most likely listed soil because it provided nutrients. Students may have concluded that if plants received nutrients in an alternate manner, soil could become nonessential.

2. Answers should indicate that students recognized that the factors listed in Part 1 determined some aspects of the garden setup and how their design addressed each essential factor, including light, nutrients, and water.

3. Answers will vary. Any changes made should be tied to initial garden performance.

4. Answers will vary. For example, students might explain how they made the nutrient solution last for the two week duration of the activity.

5. Answers will depend on students' observations. Answers should include that a lightweight, durable hydroponic garden could supply food on long space voyages and that because hydroponics is independent of soil, crops can be grown indoors in cold climates. Hydroponics offers a solution for areas with only salt water sources or land with poor soil.